5.56 mm Case Mouth Waterproofing Product Development For High-Speed Manufacturing

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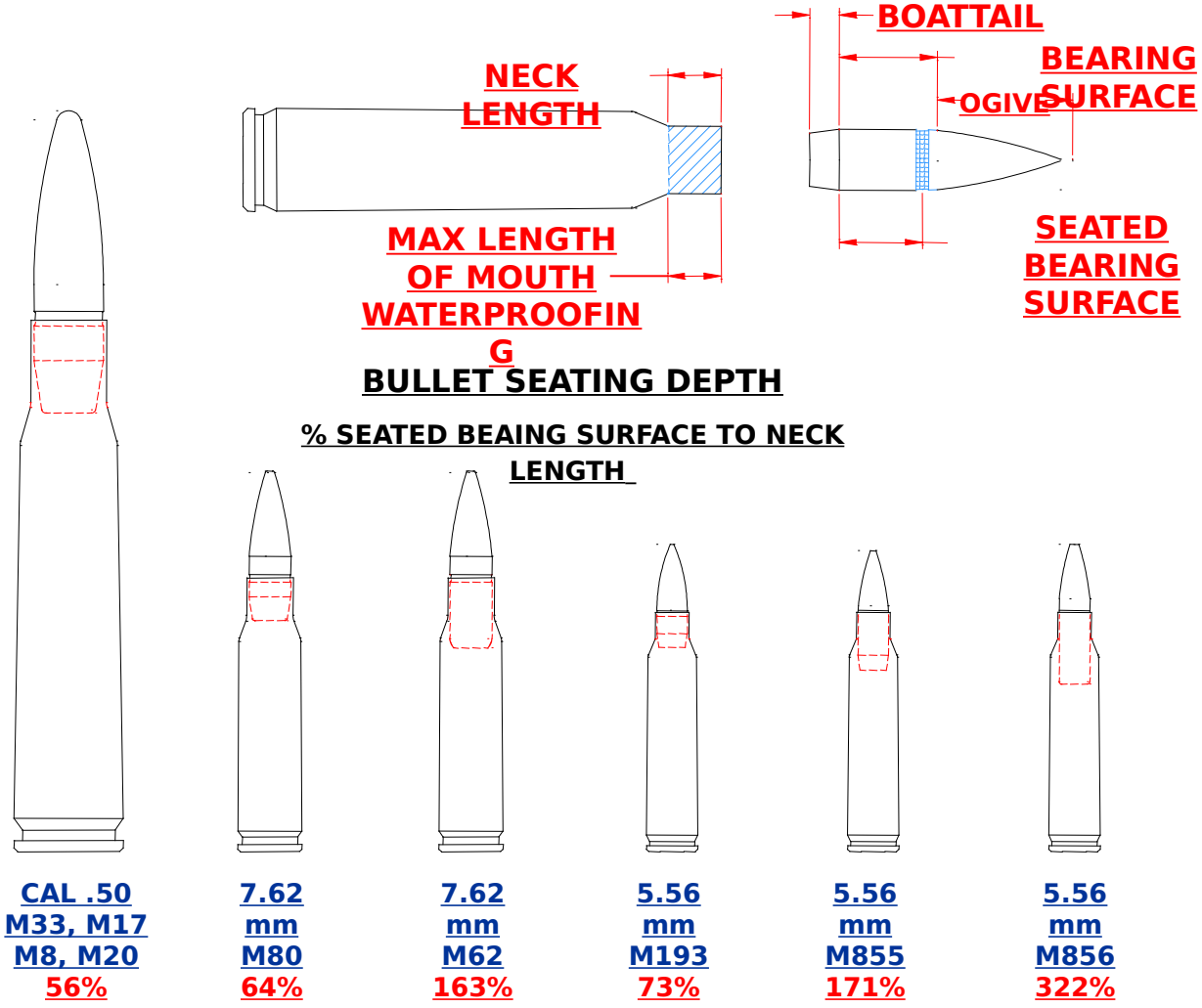
The Need For Waterproof Ammunition Is Critical

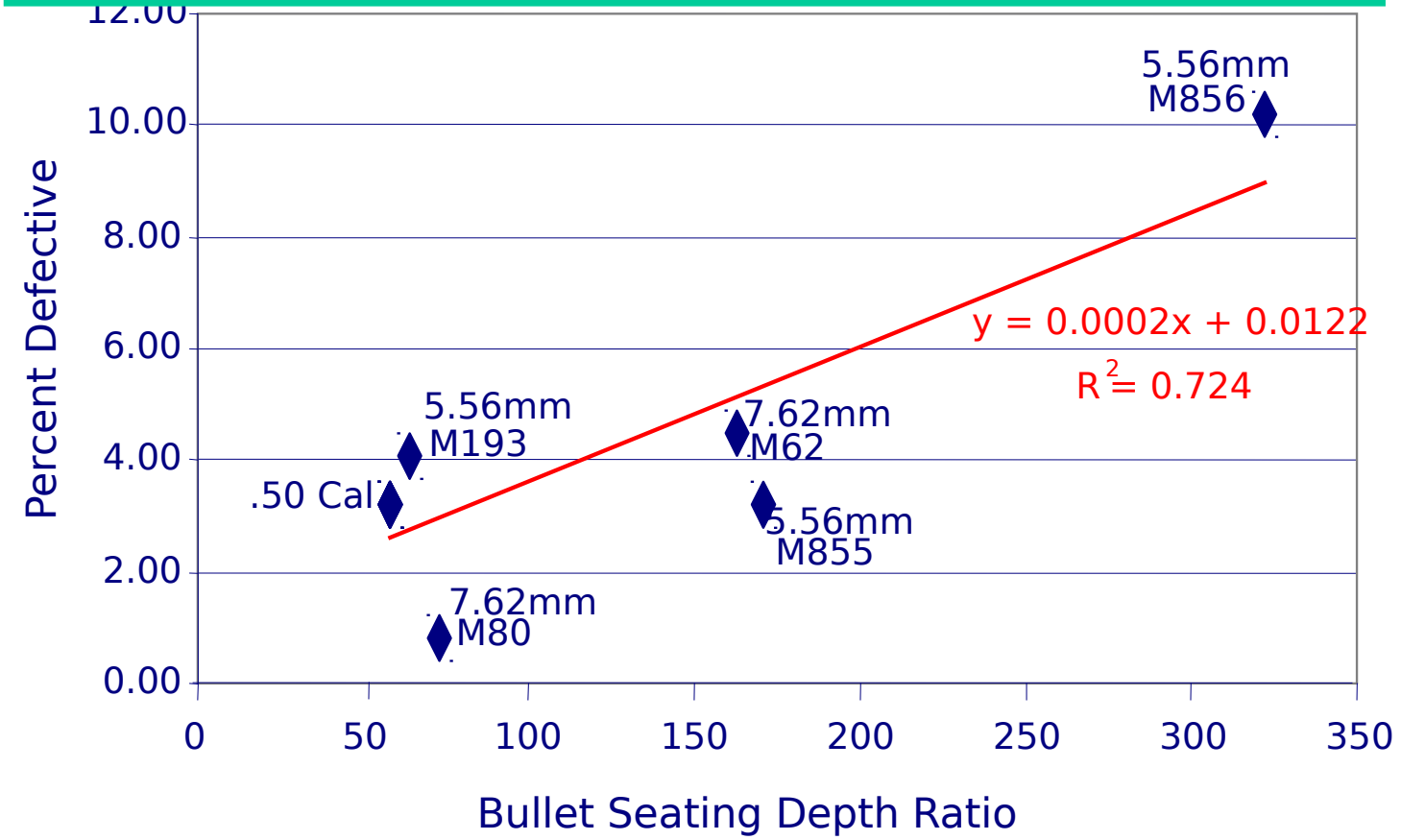
- **Not limited by geography**
- **End-users are divese**
- **Work focused on small caliber ammunition**

Current Mouth Waterproofing: An Internal Application

Illustration of Mouth Waterproofing Challenge

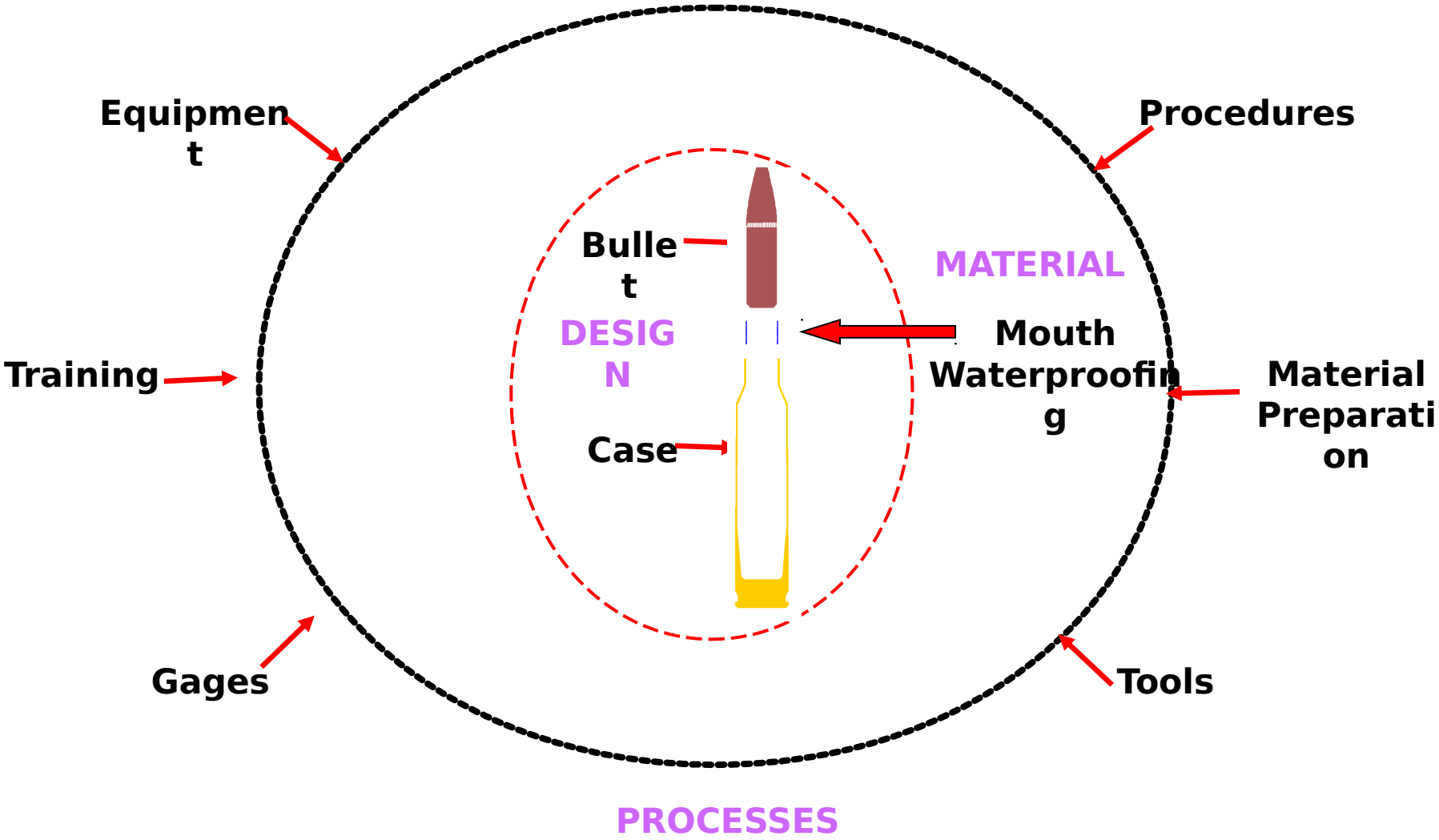


Cartridge Comparison/Waterproofing 50-Cal, 7.62 mm, and 5.56mm

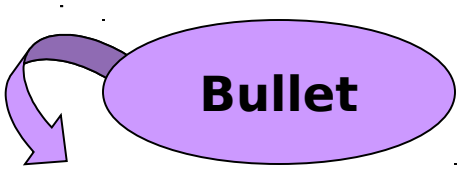


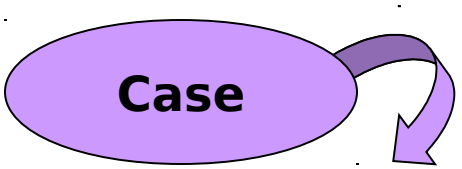
Problem Statement: Challenge is 1200 ppm Application Speed of

Short Term Fault Tree Analysis of Design, Materials and Processes



Design Factors: Full Factorial Experiments





Proposed Bullet Improvements:

- Double Cannelure
- Step on Tail End
- Knurl MWP Slot
- Knur-less
- Lower Lip
- Boat Tail
- Bulge
- Wedge

Proposed Case Improvements:

- Chamfer Mouth/Flare Mouth/Base Bulge
- Crimp Loading Method/Double Crimp
- Bullet-Case Dimensional Relations
- se Taper Mouth/Taper Mouth
- ce Condition of Contact Area

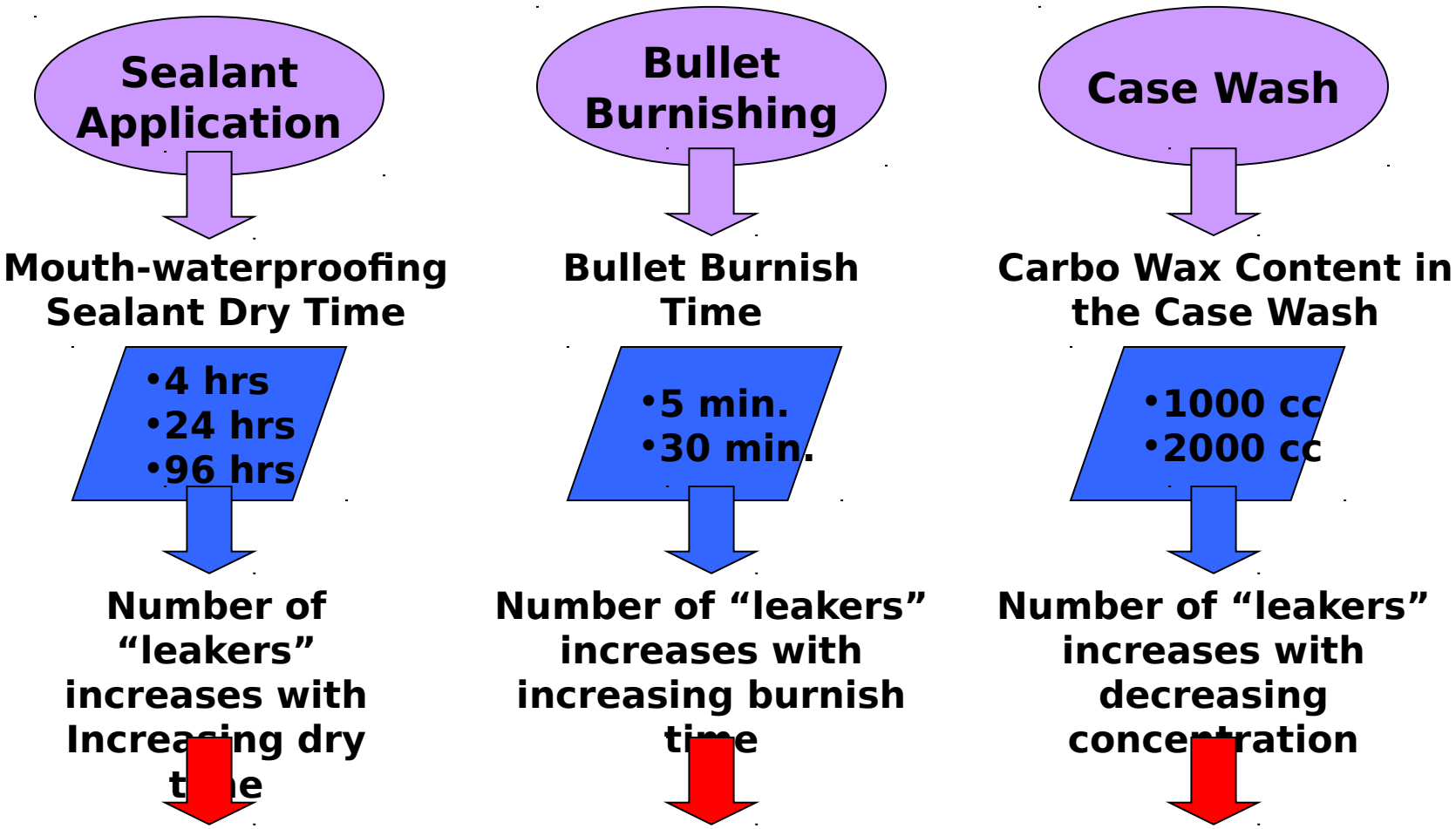
Two Experiments
Cannelure Depth
Flared Mouth
Waterproofing

Undesired Significant Effect of Cannelure Depth

No Significant Effect of Flared Mouth

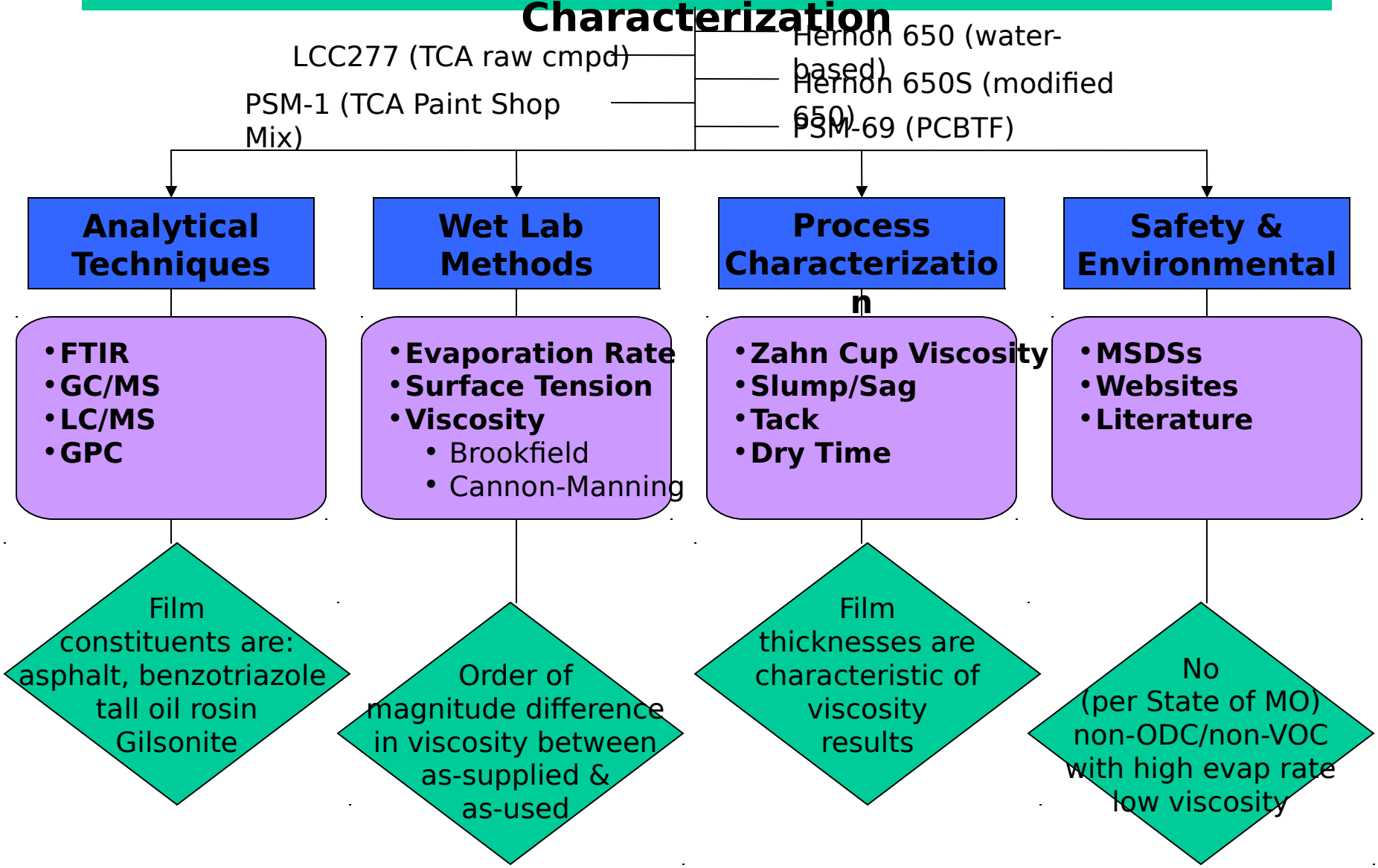
Design Factors Did Not Improve Waterproofing Performance

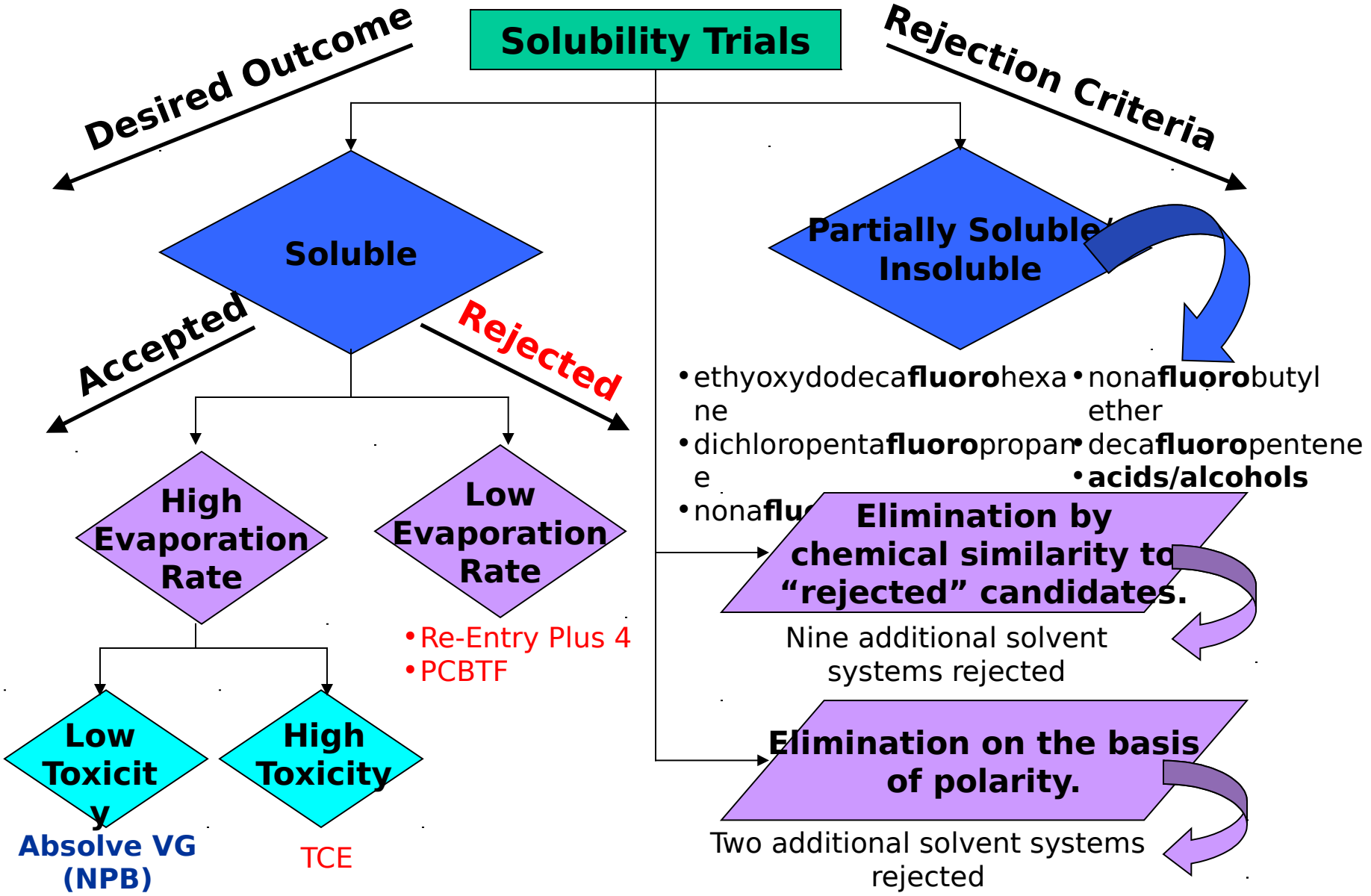
Processes: Full Factorial Experiments Material Prep



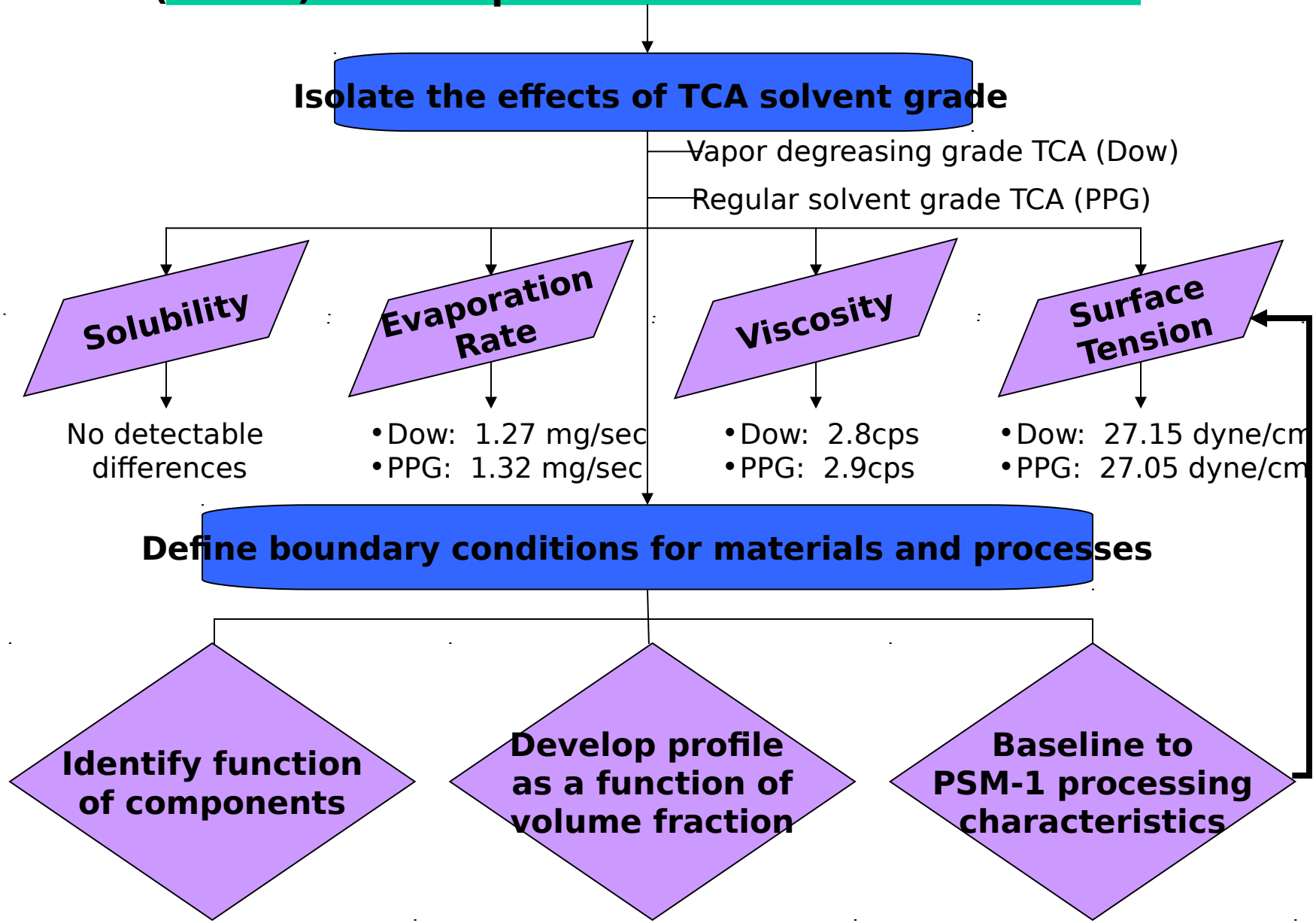
Standard Operating Procedures were revised to cause improvement
and reflect the most favorable condition.

Material: Case Mouth Waterproofing Sealant Characterization




Solubility Trials
Desired Outcome
Rejection Criteria
Soluble
Accepted
Rejected
Partially Soluble/
Insoluble
• ethyoxydodecafluorohexane
• dichloropentafluoropropane
• nonafluo
• nonafluorobutyl ether
• decafluoropentene
• acids/alcohols
High Evaporation Rate
Low Evaporation Rate
• Re-Entry Plus 4
• PCBTF
Elimination by chemical similarity to "rejected" candidates.
Nine additional solvent systems rejected
Low Toxicity
High Toxicity
Absolve VG (NPB)
Class II ODC
TCE
Elimination on the basis of polarity.
Two additional solvent systems rejected
Total of 26 solvent systems evaluated!

Characterize the existing mouth waterproofing solution (PSM-1) with respect to solvent selection criteria

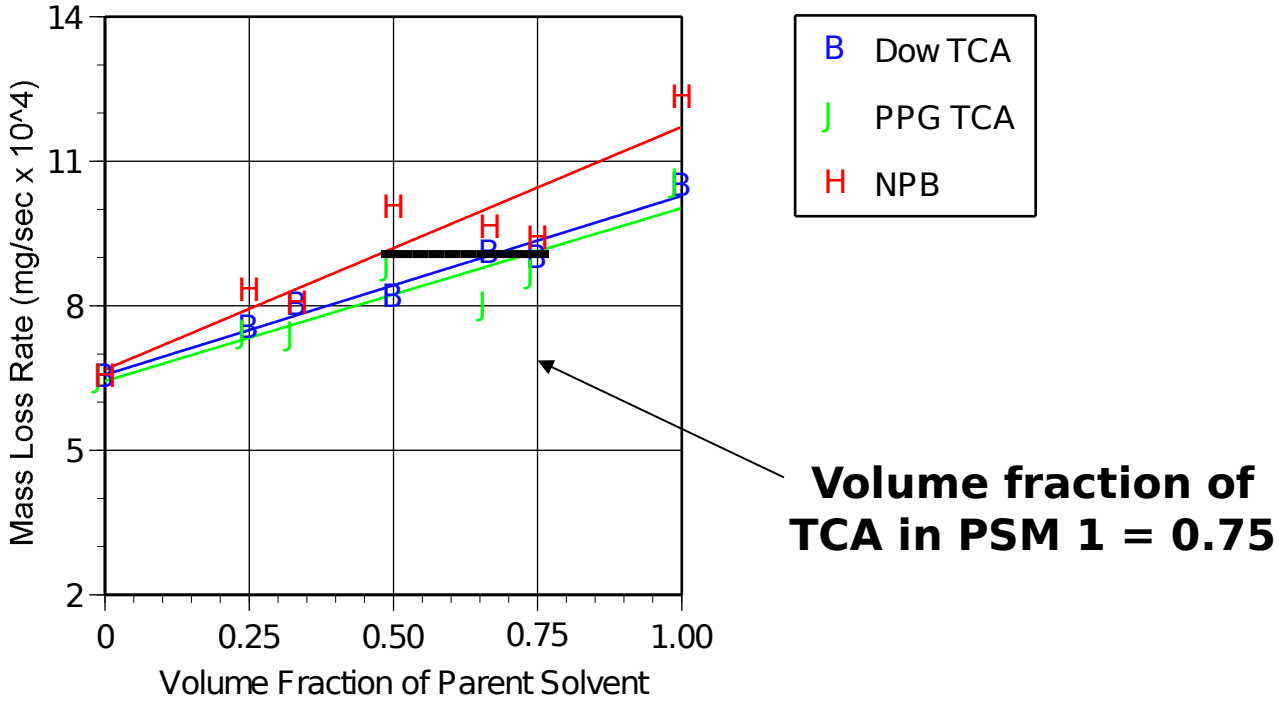


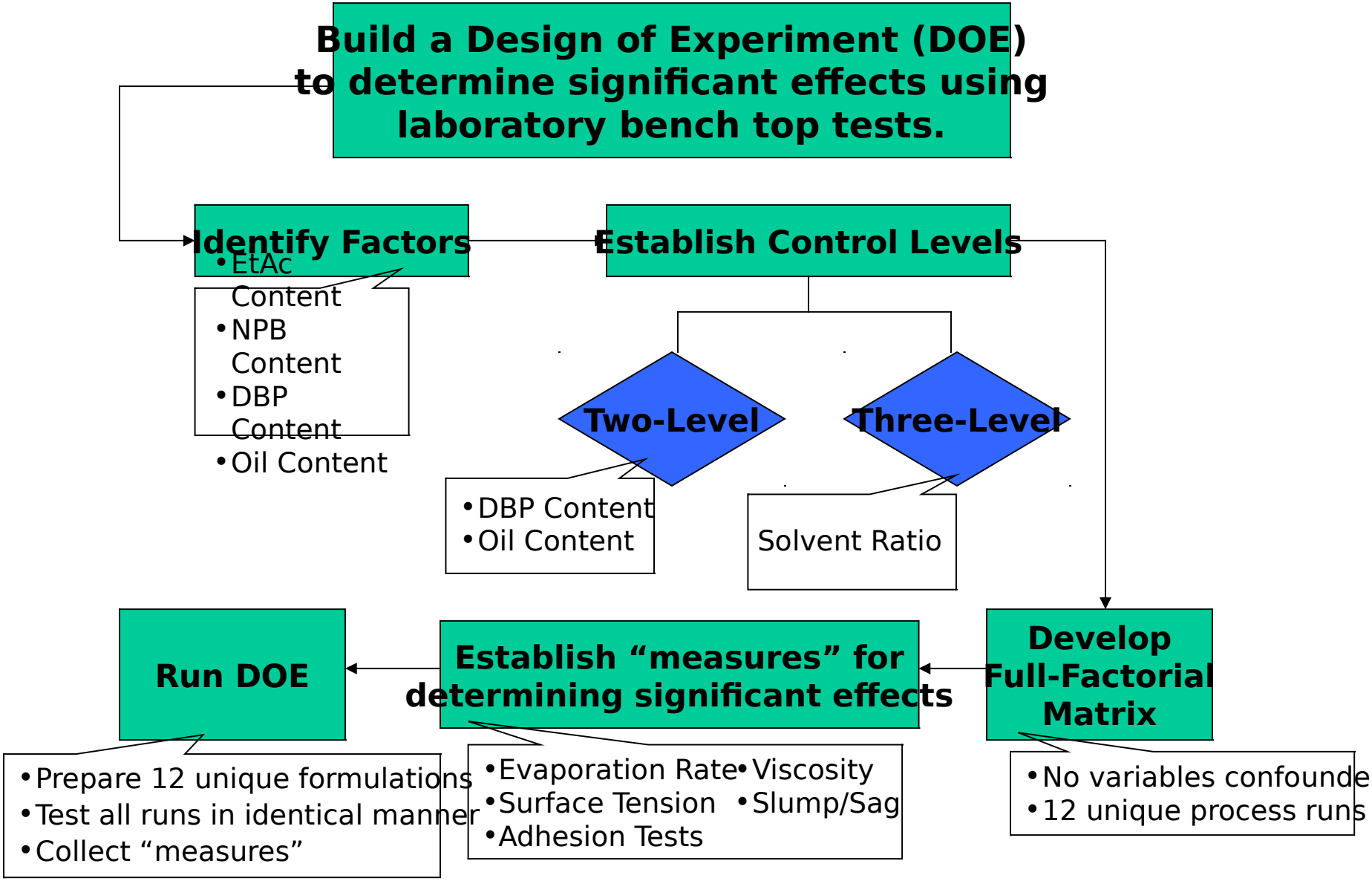
Define boundary conditions for materials and processes

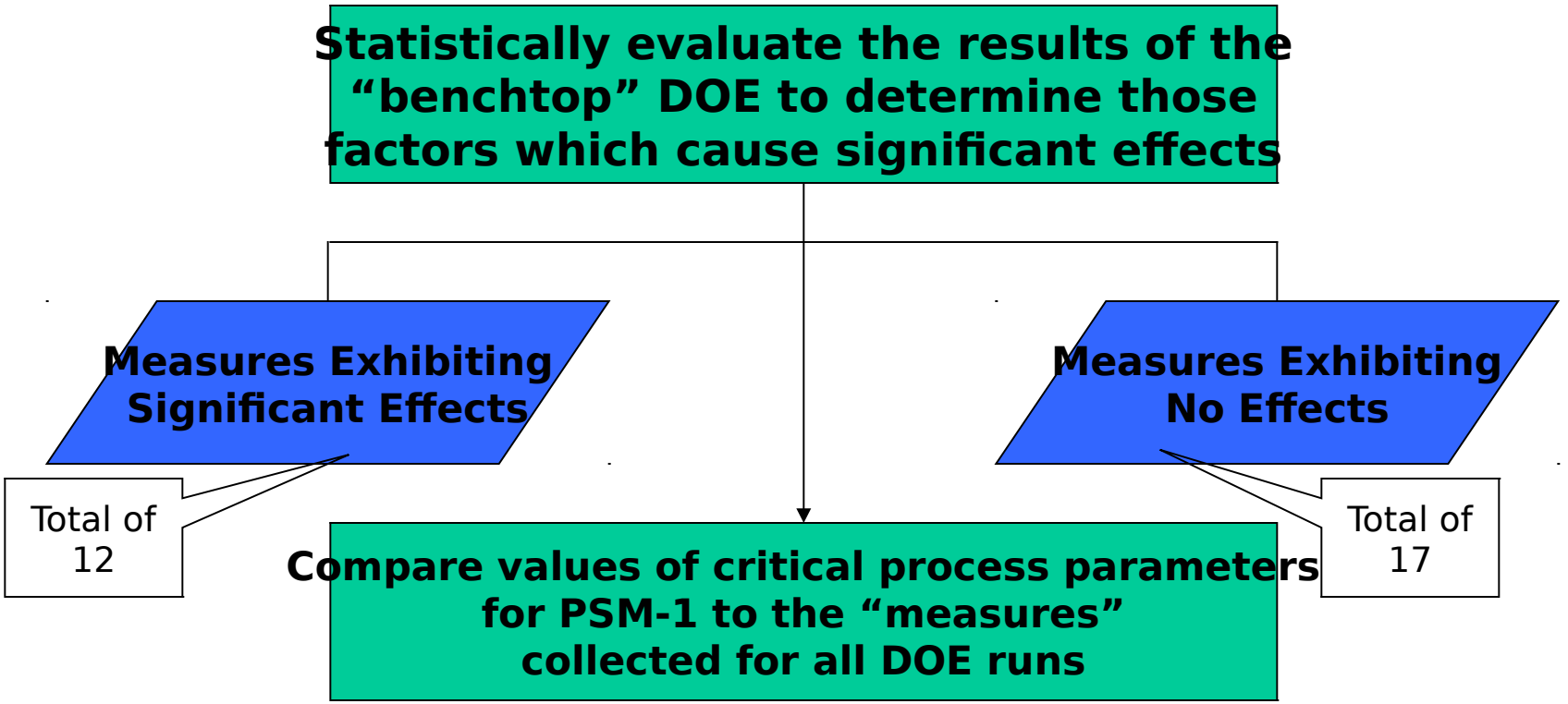
Identify function of components

Develop profile as a function of volume fraction

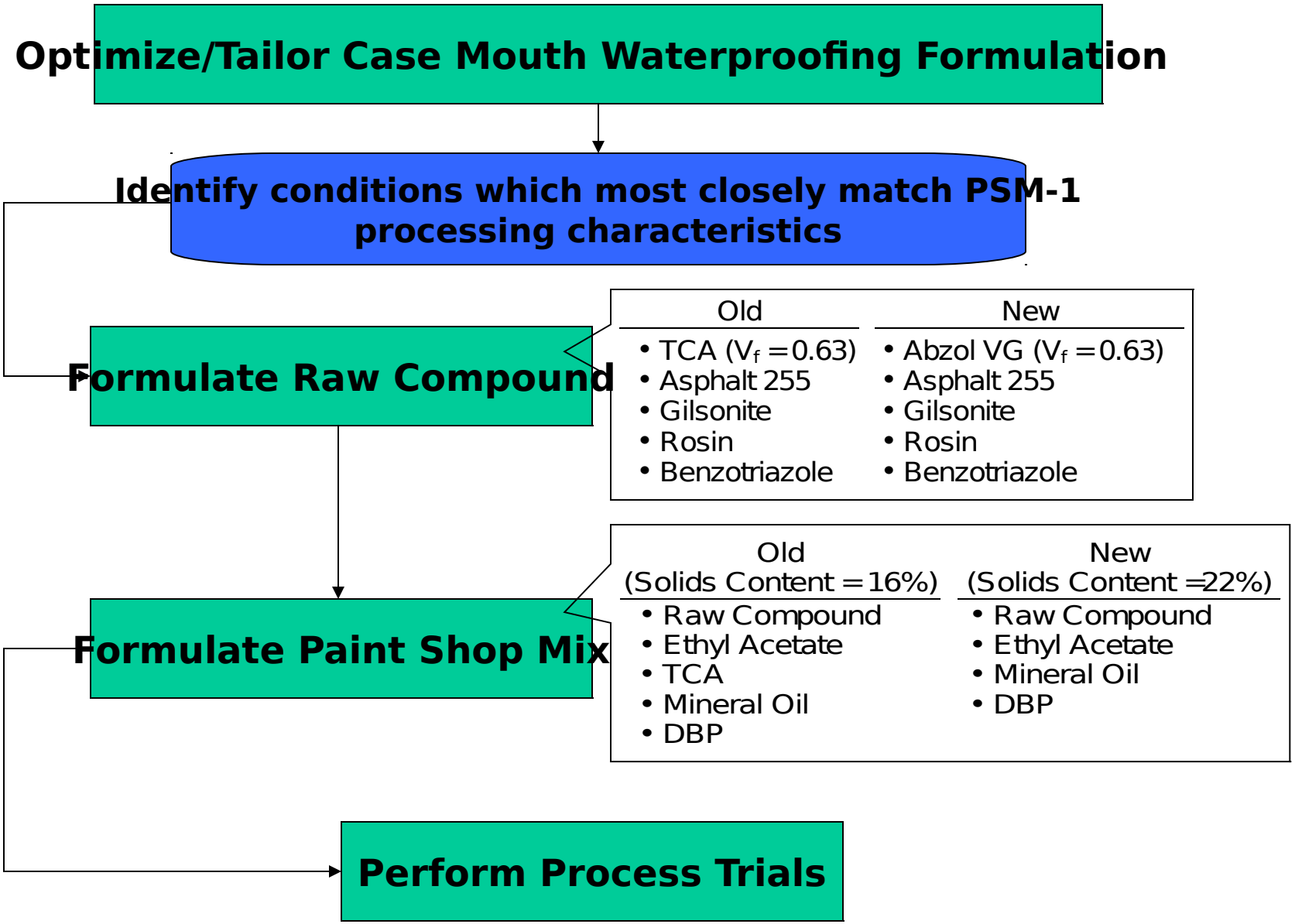
Baseline to PSM-1 processing characteristics




Build a Design of Experiment (DOE) to determine significant effects using laboratory bench top tests.
Identify Factors
•EtAc Content
•NPB Content
•DBP Content
•Oil Content
Establish Control Levels
Two-Level
•DBP Content
•Oil Content
Three-Level
Solvent Ratio
Develop Full-Factorial Matrix
•No variables confounded
•12 unique process runs
Establish "measures" for determining significant effects
•Evaporation Rate
•Viscosity
•Surface Tension
•Slump/Sag
•Adhesion Tests
Run DOE
•Prepare 12 unique formulations
•Test all runs in identical manner
•Collect "measures"


Statistically evaluate the results of the "benchtop" DOE to determine those factors which cause significant effects
Measures Exhibiting Significant Effects
Measures Exhibiting No Effects
Total of 12
Total of 17
Compare values of critical process parameters for PSM-1 to the "measures" collected for all DOE runs

Solution	Evaporation Rate (mass change in grams per sec)	Surface Tension (dyne/cm)	Viscosity (cps)
PSM-1 with Dow TCA	1.272×10^{-3}	27.2	2.8
PSM-1 with PPG TCA	1.321×10^{-3}	27.1	2.9
DOE Run #5	1.350×10^{-3}	27.2	3.0
DOE Run #6	1.386×10^{-3}	26.9	2.9
DOE Run #7	1.408×10^{-3}	26.8	2.9
DOE Run #8	1.342×10^{-3}	26.4	2.9


Optimize/Tailor Case Mouth Waterproofing Formulation
Identify conditions which most closely match PSM-1 processing characteristics
Formulate Raw Compound
Old
• TCA (V_f = 0.63)
• Asphalt 255
• Gilsonite
• Rosin
• Benzotriazole
New
• Abzol VG (V_f = 0.63)
• Asphalt 255
• Gilsonite
• Rosin
• Benzotriazole
Formulate Paint Shop Mix
Old
(Solids Content = 16%)
• Raw Compound
• Ethyl Acetate
• TCA
• Mineral Oil
• DBP
New
(Solids Content = 22%)
• Raw Compound
• Ethyl Acetate
• Mineral Oil
• DBP
Perform Process Trials

Results of Process Trials

- **No new machine settings required**
- **Leaker rates not greater than TCA**

Percent Defective Due to "Leakers"*		
Bullet Type	PSM-1 Solvent Type	
	TCA (Ops Leak Rate Nov/Dec 02)	Abzol VG
M855	5.90	1.20
M856	9.20	6.20

*Acceptable Quality Level (AQL) is 4%.

No other quality problems introduced!

Long Term Prospective Technologies

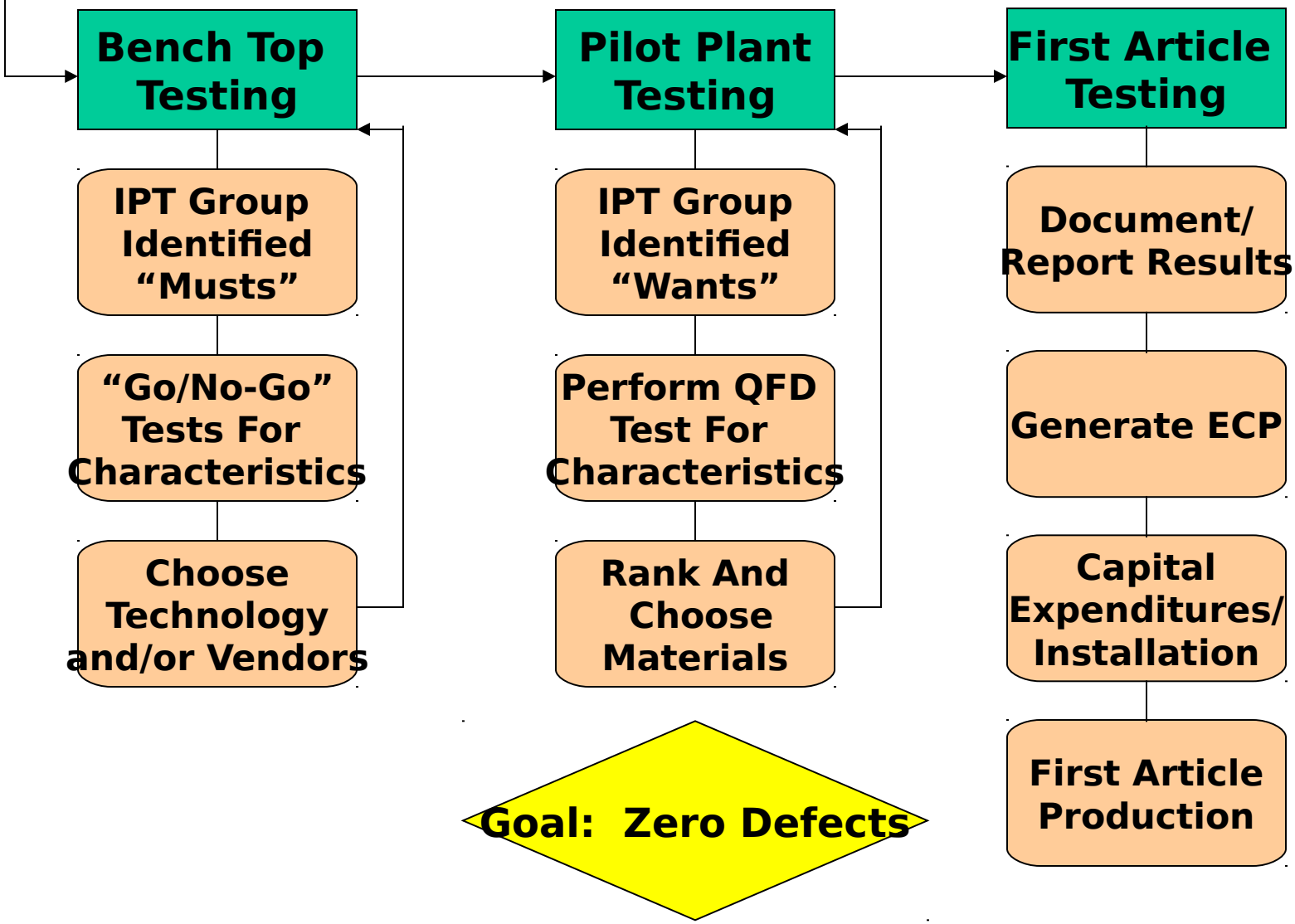
In-Joint Application

Using Capillary Action Anaerobic

Exterior Applied Coatings

Using Lacquers

Kepner-Tregoe Decision Focus



Summary

- **Waterproofing Presents Challenges**
- **Short-Term Solution: N-Propyl Bromide and Asphalt**
- **Long-Term Solution: Solventless**

Questions and Comments